King County Brightwater TREATMENT SYSTEM

Brightwater Marine Outfall Phase 3 Biological Resources Report

November 2002

King County
Department of Natural Resources and Parks
Wastewater Treatment Division

Brightwater Marine Outfall

Phase 3 Biological Resources Report

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Division

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

In November 1999, the Metropolitan King County Council approved the regional Wastewater Services Plan to upgrade King County's existing wastewater system. Included in this plan is the construction of a new regional wastewater treatment plant which will have a marine outfall to discharge treated effluent into Puget Sound waters in either northern King or southern Snohomish County.

Key biological resources and habitats within the candidate marine outfall zones were previously discussed in the *King County Marine Habitat Report*, *Phase 2 King County Biological Resources Report*, and the *King County Nearshore Habitat Mapping Data Report*. The primary purpose of this report is to provide additional information on biological resources in the Marine Outfall Siting Area that have not been addressed in previous documents. Information regarding distribution of forage fish spawning habitat, distribution and abundance data for salmonids and other marine fishes in nearshore areas, and life history and distribution data for the spot prawn within and/or near the candidate outfall zones are included in this report.

Sand lance and surf smelt spawning surveys were conducted between November 2000 and February 2001 as part of the Phase 2 biological investigation to find evidence of spawning at six beaches from Picnic Point south to Boeing Creek. Documented sand lance spawning habitat was found at Picnic Point, Ocean Avenue, Point Wells, and Richmond Beach County Park. Documented surf smelt spawning habitat was found at Picnic Point, Point Wells, and Richmond Beach County Park Additional surveys were conducted monthly from November 2001 to February 2002 at three beaches that had not been sampled previously: Brackett's Landing, Edwards Point, and Deer Creek. Documented sand lance spawning habitat was found at Brackett's Landing and Deer Creek and documented surf smelt spawning habitat was found at Edwards Point and Deer Creek.

A nearshore beach seining sampling program was initiated in 2000 in an effort to improve information regarding fish species distribution and abundance, particularly for juvenile salmonids, in King County and southern Snohomish County nearshore marine waters. The sampling program was refined in 2001 and a total of twelve sites were sampled, including five sites in or near the candidate marine outfall zones. Only data from the five sites in or near the candidate outfall zones are presented in this report. The five sites were sampled with a beach seine net bi-weekly from May 15 to October 11, 2001. A total of 17, 372 fish were captured, respresenting approximately 40 species. The number of fish caught per species ranged from 1 to 12,770. Shiner perch was the most frequently captured species, followed by English sole and chum salmon. A total of 1,605 salmonids were caught representing six species: chum, chinook, coho, and sockeye salmon, and cutthroat and steelhead trout. The most salmonids were caught at Richmond Beach and the lowest amount at Carkeek Park. For salmonids, the state of the adipose fin was recorded (i.e., whether the adipose fin was removed indicating a hatchery fish) and if the fish contained a coded-wire tag (chinook only). Over 50 percent of the chinook salmon caught had clipped adipose fins and 29 contained coded-wire tags. An additional seven

chinook which did not have clipped fins contained coded-wire tags. About 10 percent of the coho salmon captured had clipped adipose fins.

Existing data for spot prawn distribution, habitat requirements, life history, and the commercial and tribal fisheries based upon a literature review are presented in this report. Spot prawns, the largest shrimp in the Pacific northwest, are found in discrete areas called 'beds' within Puget Sound. They are most common between depths of 61 to 91 meters (200 to 300 feet) in the Central Basin and there are known beds midway between Brackett's Landing and Browns Bay and a smaller one off Point Wells. Habitat requirements vary depending upon the life cycle stage; adults are most often associated with deep, rocky bottom habitat, juveniles are associated with shallow nearshore areas, and larval stages are found in the water column.

The spot prawn fishery is divided into Management Regions and Catch Areas. The candidate marine outfall zones are within Management Region 4, Catch Area 26B and Management Region 2W (which bisects Zone 6), Catch Area 26A. The Puget Sound spot prawn fishery includes both tribal and state commercial fisheries and a recreational fishery. Since the 1994 Rafeedie Decision, Washington State Tribes and WDFW share reposnsibility for spot prawn management and allocating harvest levels equitably between tribal and non-tribal fishers. The state commercial fishery remains open for one to two months, typically from June until the end of July. The tribal fishery is an open-access fishery that does not use trip limits, therefore, the quota is usaully caught quickly and the fishery remains open only about two weeks per season. The recreational fishery is open from about April 11 to October 15. Pots are the only legal gear allowed and the minimum length must be 30 millimeters. It is illegal to pull or set pots from one hour after sunset to one hour before sunrise. The allowable tribal harvest in 2001 within Catch Area 26 was 6,000 pounds along the eastern shore from Point Edwards north to the eastern boundary of the Catch Area and seaward to 183 meters in depth. From all other waters in Catch Area 26, the allowable tribal harvest was 3,000 pounds. For catch Area 26B, the allowable tribal and state harvest was 7,300 pounds each.

1.0. INTRODUCTION

In November 1999, the Metropolitan King County Council approved the Regional Wastewater Services Plan to upgrade King County's existing wastewater system (King County Ordinance 13680, Nov. 23, 1999). Included in this plan is the construction of a new regional wastewater treatment plant in either northern King or southern Snohomish County. The new treatment plant will have a marine outfall to discharge treated effluent into Puget Sound.

The County conducted two phases of outfall site analysis in 2000 and 2001. During these analyses, the King County Council-adopted policy siting criteria were used to identify suitable locations along the shoreline of northern King and southern Snohomish Counties for the outfall and diffuser. At the conclusion of the second phase of outfall site selection, the King County Council accepted candidate marine outfall Zones 5, 6, 7N, and 7S for further analysis and review in an Environmental Impact Statement (EIS) for the Brightwater Regional Wastewater Treatment System (King County Ordinance 14278, Dec. 13, 2001). See King County 2001a, King County 2001b, and King County 2001c for complete details of the Phase 1 and Phase 2 outfall site selection process to date. Further evaluation of the approved candidate outfall zones identified outfall zones 6, 7N and 7S diffuser site B as the strongest alternatives for the outfall and diffuser (King County, 2002). These outfall zones were identified as alternatives based on land availability for construction, construction conflicts with other public services, and differences in bathymetry and currents among the outfall zones.

In January 2001, key biological resources and habitats within the candidate marine outfall zones were discussed in the *King County Marine Habitat Report* (King County, 2001d) and the *King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina* (Woodruff et al., 2001). A literature review for selected marine mammals, marine birds, marine fish, and marine invertebrates as well as habitat types in intertidal to deep subtidal areas was included in that report. In September 2001, additional information regarding biological resources within the candidate marine outfall zones was provided in the *Phase 2 King County Biological Resources Report* (King County, 2001e). Information on commercially important invertebrate species (such as Dungeness crab and geoduck clam), forage fish spawning areas, marine mammals not discussed in the marine habitat report, sub-estuaries and marine sanctuaries, and food web data was included in the *Phase 2 King County Biological Resources Report* (King County, 2001e).

1.1 Purpose and Objectives

The primary purpose of this report is to provide additional information on biological resources in the Marine Outfall Siting Study area that have not been addressed in previous documents. Specific objectives of this report are to present:

- distribution data for forage fish spawning habitat in the study area based upon new data;

- distribution and abundance data for salmonids and other marine fishes in nearshore areas within the study area collected mainly in 2001; and
- distribution and abundance data, as well as general life history information, for spot prawns based upon a literature review.

1.2 Description of Study Area

The geographic area covered by this report includes the area within the Marine Outfall Siting Study area and extends from Picnic Point south to Richmond Beach. The eastern boundary is the intertidal zone and the western boundary extends to offshore (subtidal waters) in the Central Puget Sound Basin. See Figure 1-1 for study area.

1.3 Report Organization

The remaining sections of this report provide information regarding biological resources in the Marine Outfall Siting Study area not previously reported. Section 2 provides information and data for forage fish spawning surveys conducted in the study area. Section 3 provides beach seining data for salmonids and other marine fishes in the study area. Section 4 provides biological information, including distribution and relative abundance, for spot prawns.

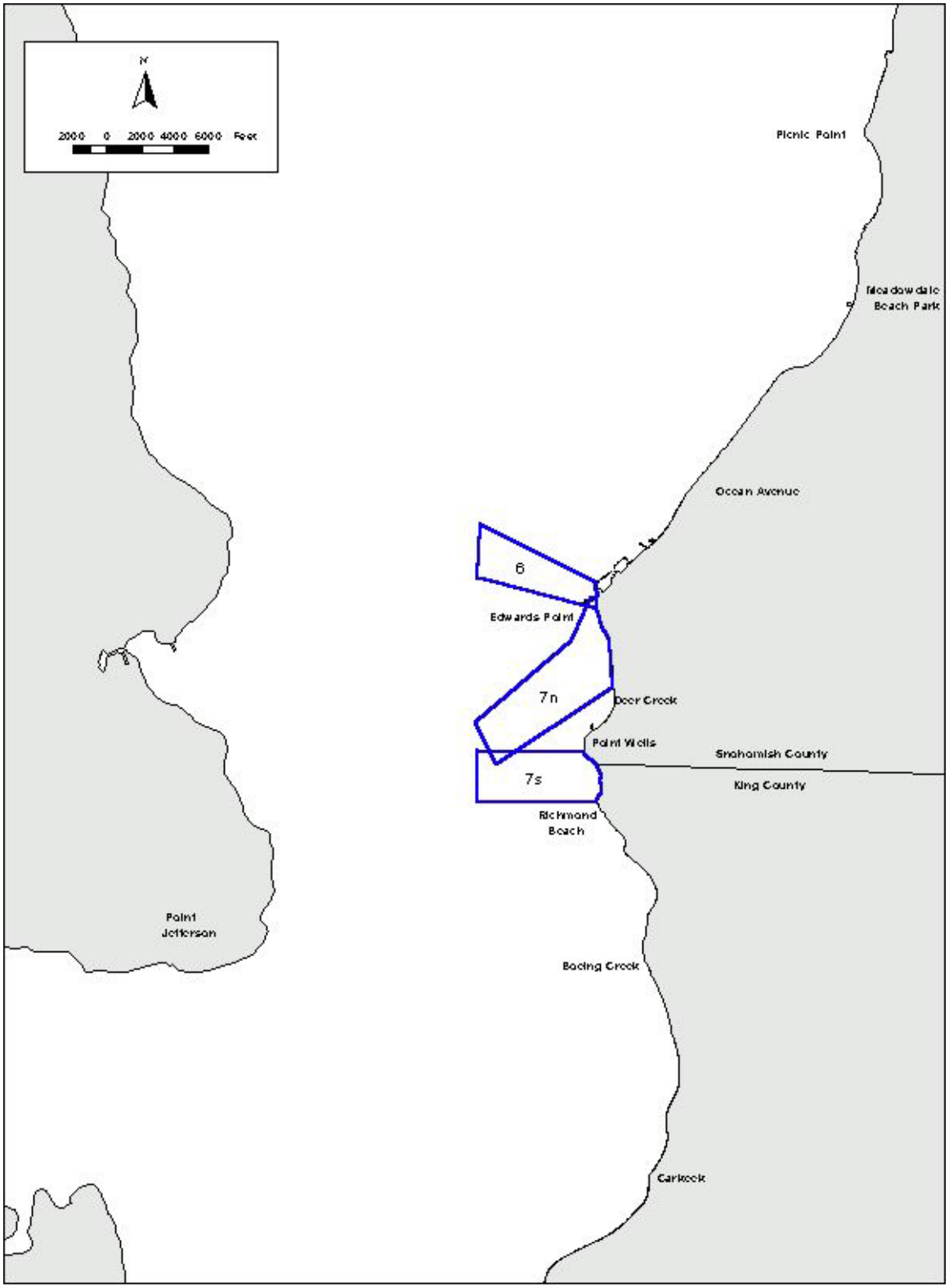

Figure 1-1. Vicinity Map Including Candidate Outfall Zones

2.0. FORAGE FISH SPAWNING AREAS

Forage fish, by definition, play a key role in food webs, being important prey for a number of predators such as fish, marine birds, and mammals. Sand lance (*Ammodytes hexapterus*), surf smelt (*Hypomesus pretiosus*), and Pacific herring (*Clupea harengus*) are three forage fish occurring in Puget Sound that use the nearshore for depositing their spawn. All three species are important for the recovery efforts of Puget Sound salmon and bottom fish. Detailed information regarding habitat requirements, life history, and distribution within the study area for these three forage fish species was provided in the *King County Marine Habitat Report* (King County, 2001d) and *King County Phase 2 Biological Resources Report* (King County, 2001e). Pacific herring typically spawn subtidally on eelgrass, macroalgae, and other firm substrates and were not included in the forage fish surveys discussed in this section. Sand lance and surf smelt spawn in intertidal areas typically on sandy sediments and were included in the forage fish surveys discussed in this section.

Sand lance and surf smelt spawning surveys were conducted between November 2000 and February 2001 as part of the Phase 2 biological investigation to find evidence of spawning at six beaches in the study area; Picnic Point Park, Meadowdale Park, Ocean Avenue, Point Wells, Richmond Beach County Park, and Boeing Creek (King County, 2001e). For those surveys, sand lance eggs were found at four sites (Picnic Point Park, Ocean Avenue, Point Wells, and Richmond Beach County Park) and smelt eggs were found at three sites (Picnic Point Park, Point Wells, and Richmond Beach County Park). No eggs of either species were found at Meadowdale Beach Park or Boeing Creek, although records in the literature indicate sand lance bury themselves in the beach at Meadowdale Beach Park (Robinette & Ha, 1997).

Additional surveys for evidence of surf smelt and sand lance spawning were conducted monthly from November 2001 to February 2002 at three beach sites in or near the candidate marine outfall zones that had not been sampled previously: Brackett's Landing, Edwards Point, and Deer Creek. See Figure 2-1 for survey sites.

2.1 Methods

In November 2000, Dan Penttila of Washington Department of Fish & Wildlife (WDFW) trained a small group of King County staff on survey methods and sample analysis. Kevin Li at the King County Environmental Laboratory led the collection of samples for the 2001/2002 surveys following the bulk sediment survey methods described by WDFW (Moulton & Penttila, 2000).

Surveys were conducted between November 2001 and February 2002 to cover the period when sand lance are expected to spawn. Surf smelt may spawn year-round and it was expected that the winter sampling would allow for evaluation of both species.

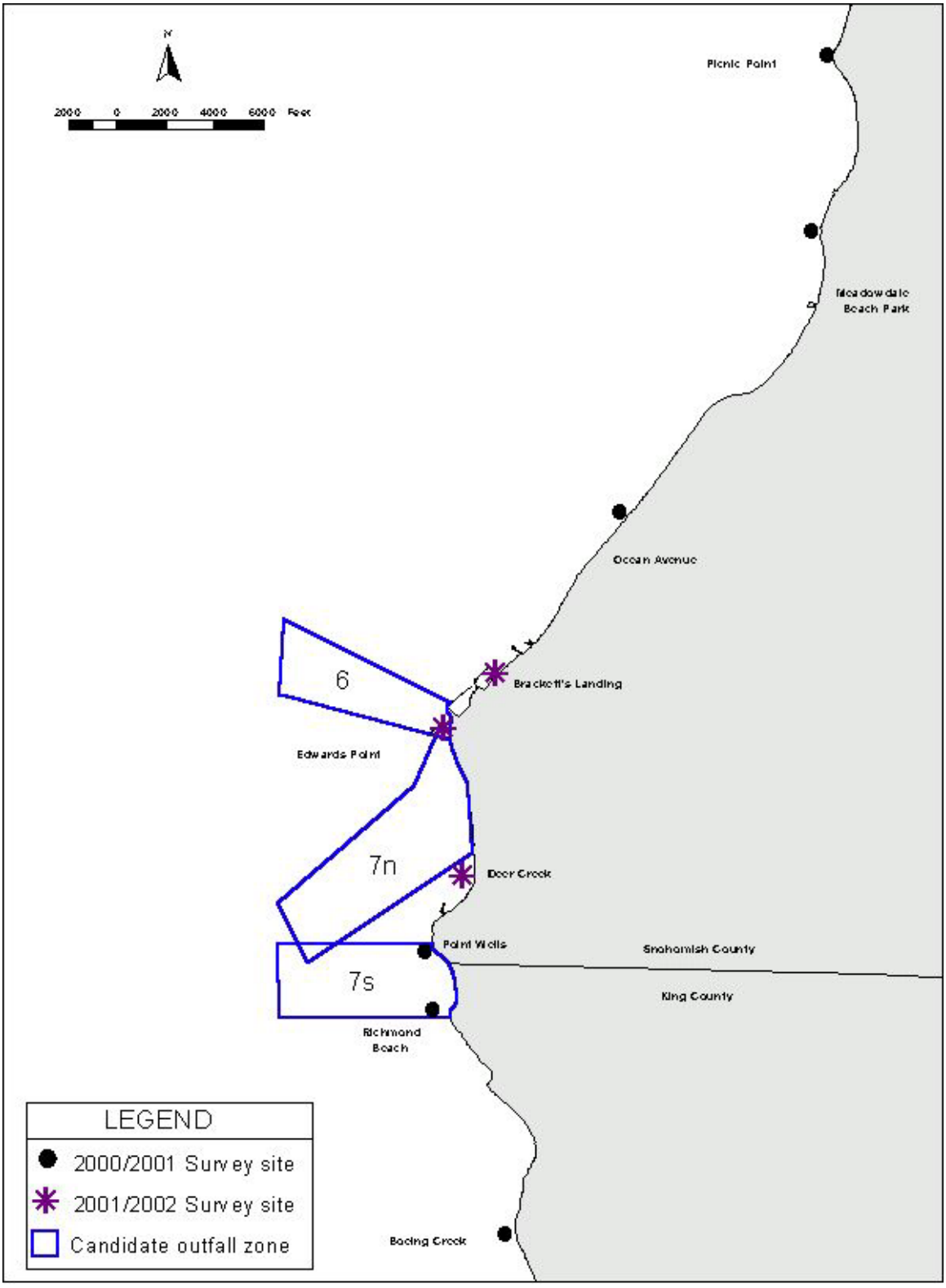

Figure 2-1. Forage Fish Spawning Survey Sites

Sediment samples were collected in areas with conspicuous shell fragments that were approximately 7 to 12 feet above mean lower low water (MLLW). Plain sand was not considered likely habitat for surf smelt, although sand lance may use this habitat type (Penttila, 2001). The number of samples collected at each site was determined by the availability of suitable habitat and time constraints. Between one and four samples were collected from each site each month. Collection locations were recorded with a Garmin Global Positioning System.

Bulk sediment sampling consisted of the collection of the top one-inch layer of beach sediment along an approximate 100-foot transect, taken parallel to the water line at 20-foot intervals. At times when substantial shell accumulations occurred in the surf zone, a single grab sample would be collected using a five-gallon bucket, rather than along a transect. The amount of sediment collected was approximately three liters per sample. The three liter sample was later winnowed in water and then sub-sampled to collect the light fraction. The winnowed volume was approximately 300 to 400 milligrams. If the winnowed samples were to be processed within a five days, they were kept refrigerated at approximately 4 ^{o}C but not preserved. If samples could not be processed within a five days, they were preserved in Stockard's solution.

In the laboratory, the winnowed samples were sub-sampled again to further concentrate the potentially egg-laden material. A Leica binocular dissecting scope was used to locate eggs. All eggs were archived in small vials with Stockard's solution as a preservative and identified to species when possible.

2.2 Sampling Site Description

All of the sites surveyed for this effort have a general westerly marine exposure and have railroad tracks and rip-rap adjacent to the shore. The railroad tracks vary in proximity to each site and range from a few meters to approximately 500 meters (1640 feet) from the sampling sites. All three sites are located between two of the sites sampled previously, Ocean Avenue and Point Wells.

Brackett's Landing is located just to the north of the Edmonds Ferry Dock and is the farthest north of the three sites sampled for this effort. Samples were taken both north and south of the jetty located at the site, although most samples were taken on the south side. The substrate is predominately sand with a gravel/cobble band in the upper intertidal area.

Edwards Point is located south of the Edmonds Marina and has an old fuel pier that divides the public access waterfront park. This site is south of the Brackett's Landing location. Samples were taken from both the north and south side of the pier. The public area south of the pier contains a dog park and is open to recreational shellfish harvesting; the north side of the pier is closed for shellfish harvesting. The substrate at this site is predominately sand and gravel.

Deer Creek beach is located south of Edwards Point and north of Point Wells. The area sampled is a straight beach (north to south) with predominately sand substrate. The area exposed during low tides is less at this site than at the other two sampled. Just north of the survey area is the Deer Creek sub-estuary where the creek enters the Sound.

2.3 Results

WDFW classifies a beach as documented spawning habitat if a minimum of two eggs for a particular species are found in at least one sample analyzed. One egg is notable and that site may warrant further sampling, however, two eggs are necessary to document the beach as spawning habitat (Penttila, 2001).

A total of 21 samples were collected on the three beaches during the survey period. A summary of the location, date collected, and eggs found is provided in Table 2-1.

A total of eight eggs were found at the Brackett's Landing, two of which were dead. Six of the eight eggs that were alive were collected in December and identified as sand lance. The two dead eggs, one identified as surf smelt the other unidentifiable, were collected in November. This site is considered sand lance spawning habitat as more than two eggs were found. Since only one surf smelt egg was found and it could not be determined if the egg was deposited at the site or washed up dead, this site is not documented surf smelt spawning habitat.

A total of four surf smelt eggs were collected in November from one sample north of the pier at Edwards Point. Therefore, this site is documented surf smelt spawning habitat. No sand lance eggs were found.

Although there were fewer samples collected at the Deer Creek site, a total of 17 eggs were found: 2 surf smelt and 15 sand lance. The two surf smelt eggs were collected in the surf zone in November documenting this site as surf smelt spawning habitat. This site is documented sand lance spawning habitat as two sand lance eggs were found in December in the surf zone and 13 were collected in January, also in the surf zone.

For the surveys conducted from November to February in 2000/2001 and 2001/2002, surf smelt eggs have been found during two of the four months: November and December. Sand lance eggs conducted during that same period of time have been found during three of the four survey months: December, January, and February.

Surf smelt and sand lance spawning habitat for the forage fish spawning surveys conducted between 2000 and 20002 have documented spawning habitat at the sites listed below in Table 2-2.

Table 2-1
Summary of Sample Locations, Collection Date, and Results

Site	Date	Sample Number	Latitude/Longitude (NAD 83)			Number of Eggs/Species Found	Comments
Brackett's Landing	14-Nov-01	#1	N47	48	49.9	0	Not likely spot for eggs, with little shell debris; S side, up against jetty
			W122	22	56.4		
	14-Nov-01	#2	N47	48	52.3	1 surf smelt egg	Egg was dead; surf zone bucket grab
			W122	22	56.1		
	12-Dec-01	#1	N47	48	54.1	1 egg	Egg was dead; north of jetty
			W122	23	48.7		
	12-Dec-01	#2	N47	48	49.7	6 sand lance	South of jetty
			W122	22	56.1		
	15-Jan-02	#1	N47	48	49.9	0	South of jetty; surf zone
			W122	22	56.4		
	25-Feb-02	#4	N47	48	48.7	0	South of jetty, mid beach
			W122	22	56.4		
Edwards Point	13-Nov-01	#1	N47	48	20.1	0	200' N of pier; 20' from water, 30' from drift logs
			W122	23	42.3		
	13-Nov-01	#2	N47	48	20.3	4 surf smelt	N side of pier, higher on beach with drift eelgrass; 10' from logs
			W122	23	42		
	13-Nov-01	#3	N47	48	13	0	S. of pier, 25' from water, just below drift eelgrass
			W122	23	40.3		
	13-Nov-01	#4	N47	48	16.7	0	N side of pier, small grab in a big patch of shell adjacent to boulders
			W122	23	40.9		
	12-Dec-01	#1	N47	48	14.9	0	mid beach, 10' up from surf
			W122	23	40.3		
	15-Jan-02	#1	N47	48	13.7	0	mid beach, south end; 20' from water, 15' to driftwood
			W122	23	39.8		
	15-Jan-02	#2	N47	48	17.1	0	mid level, close to pier, 50' from fence
			W122	23	40.8		
	25-Feb-02	#1	N47	48	13	0	S of pier; mid beach, 15' up from surf; good shell aggregate
			W122	23	40.4		
	25-Feb-02	#2	N47	48	13	0	surf zone grab; good shell aggregate
			W122	23	40.4		
	25-Feb-02	#3	N47	48	20.7	0	Northern portion of beach, slight shell accumulation
			W122	23	42.2		
Deer Creek	27-Nov-01	#1	N47	47	13.6	2 surf smelt	Sandy beach N of Pt Wells; but little shell; surf zone bucket grab
			W122	23	27		
	19-Dec-01	#1	N47	47	12.6	2 sand lance	surf zone
			W122	23	26.9		
	19-Dec-01	#2	N47	47	21	0	by south end of big mudslide
			W122	23	27.5		
	16-Jan-02	#1	N47	47	9	13 sand lance	surf zone grab
			W122	23	29.7		
	26-Feb-02	#1	N47	47	13.7	0	surf zone bucket grab
			W122	23	26.8		

Table 2-2
Documented Spawning Habitat Sites

		Documented Spawning Habitat (minimum of two eggs)	
Site	**Date Sampled**	**Sand Lance**	**Surf Smelt**
Picnic Point	Nov. 2000 - Feb. 2001	●	●
Meadowdale Beach Park	Nov. 2000 - Feb. 2001		
Ocean Avenue	Nov. 2000 - Feb. 2001	●	
Brackett's Landing	Nov. 2001 - Feb. 2002	●	
Edwards Point	Nov. 2001 - Feb. 2002		●
Deer Creek	Nov. 2001 - Feb. 2002	●	●
Point Wells	Nov. 2000 - Feb. 2001	●	●
Richmond Beach County Park	Nov. 2000 - Feb. 2001	●	●
Boeing Creek	Nov. 2000 - Feb. 2001		

3.0. 2001 NEARSHORE BEACH SEINING PRELIMINARY RESULTS

Historical data regarding fish species composition in nearshore marine waters of Puget Sound are extremely limited. In particular, nearshore fish surveys in King and southern Snohomish Counties have never been conducted to determine fish species composition, timing, distribution, and habitat utilization. While a number of studies (i.e., Fresh et al., 1981; Simenstad et al., 1982; Healy, 1982) provide the basis for understanding salmonid early marine life history, few studies have surveyed outside of river-mouth estuaries and none have been conducted along the north King County and south Snohomish County shoreline. This section presents a summary of the methods and results of a survey to determine distribution, relative abundance, and species composition for salmonids and other marine fishes in the nearshore areas of northern King County and southern Snohomish County. Complete documentation of methods and results of this study, along with results from other sites surveyed in King County, will be provided in a separate report currently in preparation.

3.1 Introduction

Saltwater habitats used by anadromous salmonids provide a critical component of their life histories (Thom, 1987; Simenstad et al., 1991; Spence et al., 1996). In the Puget Sound estuary, adults use nearshore marine waters for migration and feeding, while juveniles are known to depend upon nearshore waters for migration, feeding and refuge. The estuarine environment is also an important physiological transition area for juvenile chinook and other salmonid smolts (Healy, 1980). Furthermore, shallow nearshore waters provide important prey production functions in addition to critical nursery habitat for a broad range of fishes and invertebrates.

To improve understanding of fish species composition, particularly juvenile salmonid timing, distribution, and abundance in King County and southern Snohomish County nearshore waters a beach seining pilot study was initiated in 2000, The 2000 pilot study concentrated on sampling logistics and development of a nearshore fish catch baseline. Building on what was learned in the 2000 pilot program, a study was designed for 2001 to sample throughout King and southern Snohomish Counties. Emphasis was placed on standardizing sampling design and data collection. A total of 12 sites were sampled in 2001, with seven sites in central and southern King County and five sites in northern King and southern Snohomish Counties. Methods and results for the five sites in northern King and southern Snohomish Counties which are in or near the candidate marine outfall zones will be discussed in this report.

In 2001, bi-weekly beach seine surveys were conducted from May to October. All fish captured were identified, enumerated and a subsample of each species was measured to the nearest millimeter. Although the primary purpose of this study was to learn more about species composition, timing and distribution, an emphasis was placed on data collection that would provide additional information about juvenile salmonids, especially chinook. Therefore, in addition to identifying, counting and measuring salmonids, a

subsample of juvenile chinook and other salmonids were lavaged or retained for dietary analysis to improve upon previous knowledge of food web linkages. In addition, salmonids were checked for coded wire tags and adipose fins were noted as present or absent (i.e., clipped/unclipped).

3.2 Objectives

While the results of the 2001 study reported here are preliminary and summarize catch data, the specific objectives of the study were to:

- sample a broad geographic area within King and south Snohomish Counties to determine differences in fish species composition (timing, distribution and abundance);
- develop a standard for sampling, data collection, and characterizing/classifying habitat type that could serve as a basis for future studies and help in distinguishing differences in fish species composition;
- measure temporal and spatial distribution of salmonids by species and size;
- collect gut contents of juvenile salmonids to determine prey composition;
- distinguish adipose clipped vs nonclipped fish to help distinguish hatchery from possible wild fish;
- identify and collect coded wire tagged salmonids to help distinguish hatchery from wild fish and determine point of origin/release, distribution, time at large and growth; and
- measure a subsample of all species to determine size classes of individual species utilizing nearshore marine waters.

3.3 METHODS

This section presents methods used for sample collection and sample processing.

3.3.1 Sample Collection

Beach seining surveys were conducted bi-weekly in marine nearshore waters at 12 preselected sites in King County and south Snohomish County. The five sites surveyed in north King County and south Snohomish County included Picnic Point, Meadowdale Park, Ocean Avenue, Richmond Beach and Carkeek Park (Figure 3-1). Sites were sampled between May 15, 2001 and October 11, 2001. Each site was sampled during daylight hours and at tidal elevations that varied by the date and time of day they were sampled. No effort was made to sample at preselected tidal elevations (i.e., low tide). During May, three non-overlapping sets of the beach seine were made at each site. During the remainder of the study period, two non-overlapping sets were made at each site due to time constraints. Use of two instead of three beach seine sets allowed for completetion of three site surveys within an eight hour period for a single day.

The beach seine (net) used for this study was designed according to the specifications in *Puget Sound Estuary Program, Estuary Habitat Assessment Protocol* (Simenstad et al.,

1991). The gear and sampling procedure were identified prior to field sampling as the standard for shallow, nearshore fish sampling in Puget Sound and the net is commonly called a "Puget Sound beach seine". The equipment consisted of a 37-meter long by 2-meter high, floating beach seine with tapered wings (2.56 cm stretch mesh) and a bag (0.6 m wide by 2.4 m deep by 2.3 m long, 0.6 cm stretch mesh) centered between the wings. Thirty-meter haul lines were attached to a harness at the ends of the wings.

The net was set parallel to shore using a motorized vessel and staff standing on shore. The seine set began with a person standing at the water line on the beach holding one end of the haul line as the boat backed away from and perpendicular to shore, feeding out the line until the boat was 30-meters from shore. The boat was then turned parallel to shore and the net was released (set) as the boat ran parallel to shore. Once all of the net was released, the haul line at the other end of the net was returned to another person standing on the shore, approximately 40-meters down the beach from the first person.

Once the net was in place, the haul lines were then pulled simultaneously, at an equal rate, and at a slightly oblique angle to form a wide arch of the net passing through the water and toward shore at a rate of approximately 10m/min. When the net was approximately 10-meters from shore, the individuals retrieving the net at each end would approach one another so the net opening closed to approximately 12-meters as the landward ends of the wings touched the beach. The wings were then drawn closer to within approximately 3-meters as the wings were drawn up onto the beach, making sure the lead line remained on the bottom and forcing all fish down the wings and into the bag. Once the lead line along the bag of the net reached the beach, the lead line and float lines were lifted simultaneously. Any fish remaining in the wings were worked down into the bag and the bag was pulled back out into approximately 0.5-meter depth of water to maintain a sufficient amount of water in the bag for the catch. Debris and fish were removed from the bag, with the fish being transferred to 5-gallon buckets of fresh seawater.

3.3.2 Sample Processing

All fish were identified to the lowest taxonomic classification that could be made with confidence and then counted. A minimum of 10 fish of each species were retained for measurements of fork length or total length, depending upon the species. Occasionally, accurate counts were not recorded due to excessively high numbers of an individual species and in an attempt to reduce potential mortality and handling time, exact counts were not recorded. Occasionally, accurate counts were not recorded due to errors made by inexperienced staff.

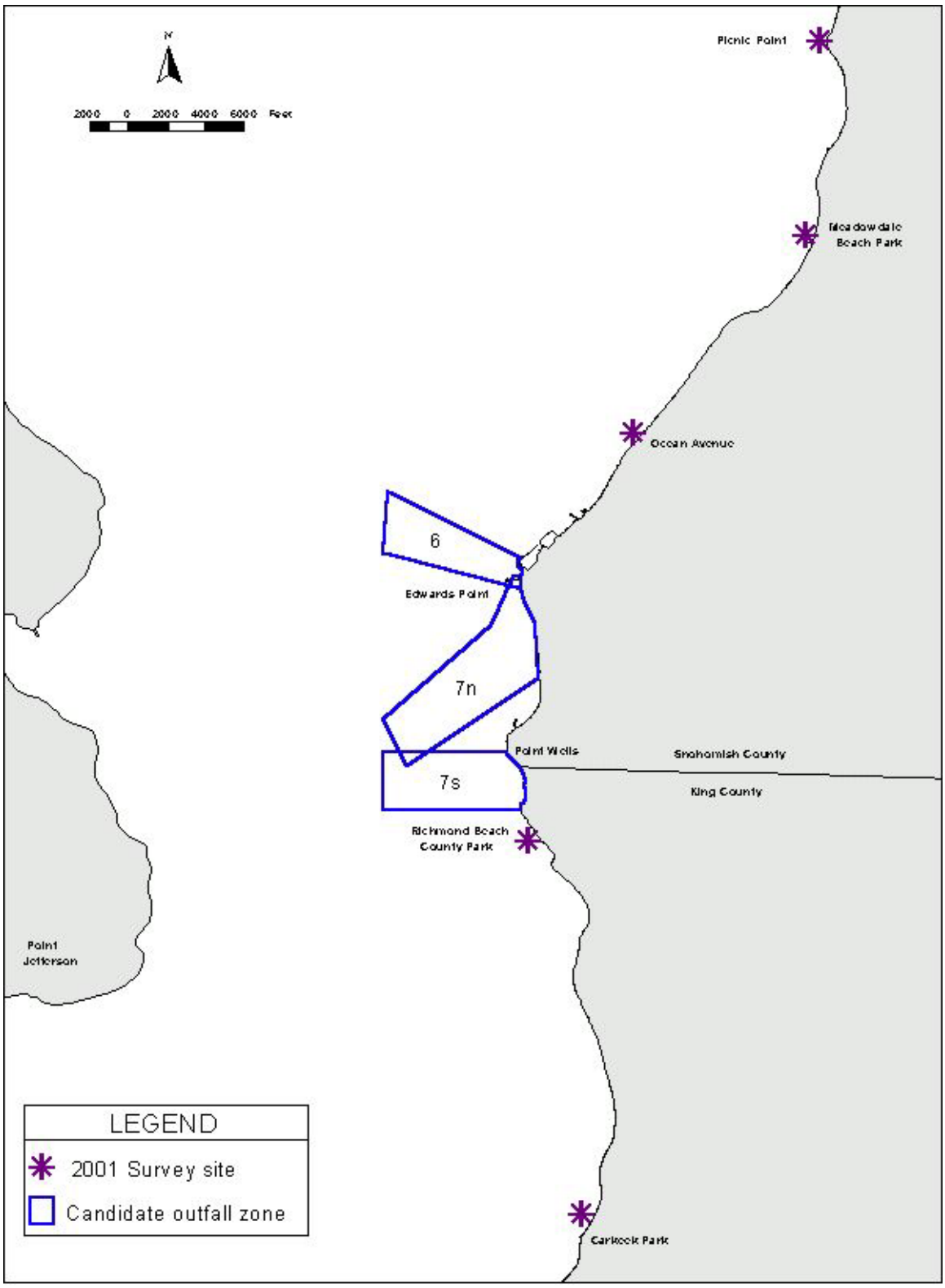

Figure 3-1. Beach Seining 2001 Survey Sites in MOSS Area

All fish captured were transferred to buckets of seawater at a processing station, which was set up on the beach prior to deploying the seine. At this station, fish were maintained in aerated buckets of seawater until they could be measured. If necessary (i.e., during warm weather, or if processing took a long period of time), water was exchanged with fresh seawater to maintain oxygen levels and cool water temperature. A minimum of 10 fish of each species were measured on a wetted measuring board, with the length (total or fork, depending upon the species) called out to a data recorder. The species and length data were recorded on preprinted waterproof ("Rite-in-the-Rain") data sheets. Fish were allowed to recover in an aerated 30-gallon cooler of fresh seawater and subsequently released away from the area where a subsequent set of the net would be made.

For salmonids captured in the seine, processing required the collection and recording of additional data. Salmonids were usually processed first because they are typically more sensitive to handling and required more recovery time. Individual salmonids were immersed in a bath of fresh seawater that contained a mild anesthetic, MS-222, to sedate them prior to taking measurements, or performing gastric lavage (see below). Once sedated, salmonids were identified to species, measured, and allowed to recover in the aerated recovery tank. All chinook and coho salmon were checked for adipose fin presence or absence (i.e., clipped or unclipped) and chinook were checked for coded-wire tags (CWT) using a Northwest Marine Technologies (NMT) magnetometer. Coded-wire tagged fish were retained, labeled and preserved for transport to the Washington Department of Fish and Wildlife in Olympia for tag extraction and decoding.

Early in the sampling season, a subsample of whole salmonids (chinook, chum, and coho) were collected for dietary analysis. Samples consisted of whole fish due to the lack of lavage equipment and the desire to utilize CWT fish that were already being sacrificed for CWT extraction and decoding. Only clipped or CWT chinook were collected for dietary analysis to avoid sacrificing wild fish. Fish were identified, measured, labeled and preserved (by freezing) for later stomach removal and analysis of stomach contents. This procedure was replaced with gastric lavage to avoid sacrificing fish. Gastric lavage is a procedure used to flush the stomach contents out of the foregut of the anesthetized fish. A 60 cubic centimeter syringe fitted with a blunt needle was filled with filtered seawater. The needle was then carefully inserted along the roof of the mouth, down the esophagus and into the foregut. Seawater was then forced into the gut, which flushes stomach contents out through the mouth and into a sample collection container. The samples were then labeled, preserved with 90% ethanol, and archived for later analysis. Lavaged fish were allowed to fully recover in the recovery tank and were then released back into Puget Sound at the sampling location.

In addition to fish capture data, site specific data were collected and recorded on preprinted waterproof datasheets. An individual datasheet was completed for each beach seine haul in a manner that would allow a distinction between each location, date and set. Each set location was recorded by taking Global Positioning System (GPS) coordinates in the center of the sampling location. In addition, other quantitative and qualitative environmental data (i.e., water temperature, substrate, presence/absence of aquatic vegetation) were collected to characterize each sampling location.

3.4 RESULTS

A total of five sites were surveyed with beach seine hauls in northern King County and southern Snohomish County between May 15 and October 11, 2001. A total of 117 hauls were made at the five sites during the study period, with 23 to 25 hauls made per site. Between one to six hauls made per site for each month of sampling (Table 3-1). During this study, a total of 17,372 fish were captured, representing over 40 individual species (Table 3-2). The total number of fish caught at each site ranged from 1,059 at Carkeek Park to 6,492 fish caught at the Ocean Avenue site. The number of fish captured ranged from 1 to 12,770 individuals per species. The number of species represented at each site and the number of individuals of a particular species (species diversity and abundance) varied geographically and throughout the study period. During the survey period, shiner perch was the most frequently captured species, followed by English sole and chum salmon.

3.4.1 Salmonid Results

For salmonids, a total of 1,605 fish were caught during the study period at the five sites, representing six species. Chum were the most abundant salmonid captured (n=1072), followed by chinook (n=235), cutthroat trout (n=170), coho (n=84), sockeye (n=41) and steelhead (n=3) (see Table 3-2). The highest number of salmonids was found at Richmond Beach (n=801), with the lowest number found at Carkeek Park (n=142). The highest numbers of salmonids were captured earlier in the sampling period (i.e., May, June, July) and decreased throughout the remainder of the study period (Table 3-3). Site specific catches of individual salmonid species varied throughout the season. For example, chinook catches ranged from a total of 63 fish caught at the Meadowdale site, to a low of 22 chinook caught at Picnic Point during the sampling period. It is difficult to detect patterns (if they exist) at this level of analysis as monthly totals confound the interpretation. For example, although the Meadowdale site had the highest total catch of chinook, more chinook were caught at the Carkeek Park site in the month of July than at any other site in a given month. Statistical evaluation of the data will be included in a separate report currently in preparation.

Table 3-1
Number of beach seine hauls per site by month in 2001.

	May	June	July	August	September	October	Totals
Carkeek	6	4	3	5	3	2	23
Richmond Beach	6	4	4	3	4	1	22
Meadowdale	6	4	4	4	4	2	24
Ocean Ave	6	4	4	3	4	2	23
Picnic Point	6	4	4	5	4	2	25
Totals:	**30**	**20**	**19**	**20**	**19**	**9**	**117**

Table 3-2
Summary of All Fish Caught by Site in 2001

		Picnic Point	Meadowdale	Ocean Avenue	Richmond Beach	Carkeek Park	Total per species
Salmon	Chum	66	57	204	677	68	1072
	Sockeye	0	2	0	38	1	41
	Cutthroat	45	120	1	2	2	170
	Steelhead	1	1	0	1	0	3
	Chinook	22	63	31	60	59	235
	Coho	30	16	3	23	12	84
	Total Salmonids	**164**	**259**	**239**	**801**	**142**	**1605**
Perch	Shiner perch	2801	2749	5241	1310	669	12770
	Striped perch	35	17	58	22	1	133
	Pile perch	18	3	10	3	0	34
Flatfish	English sole	259	192	479	80	55	1065
	Rock sole	122	262	32	18	32	466
	Starry flounder	65	25	9	1	29	129
	Speckled sanddab	35	48	11	1	8	103
	CO sole	2	9	11	0	1	23
	Sand sole	6	0	0	0	0	6
	Flathead sole	0	0	0	0	3	3
	Pacific sanddab	0	0	0	0	8	8
	Sanddab spp.	1	0	0	0	0	1
	Flatfish spp.	0	44	0	55	0	99
Sculpin	Staghorn sculpin	51	54	152	48	65	370
	Great sculpin	13	37	11	2	2	65
	Northern sculpin	2	3	0	1	2	8
	Buffalo sculpin	9	20	0	0	1	30
	Silverspotted sculpin	0	0	1	0	0	1
	Cabezon	0	0	4	0	0	4
	Tidepool sculpin	0	1	0	1	1	3
	Sculpin spp.	9	1	0	0	0	10
Forage Fish	Sand lance	0	22	9	0	6	37
	Surf smelt	0	6	28	2	20	56
	Herring	1	8	10	6	5	30
Gunnels	Penpoint gunnel	10	0	46	5	2	63
	Crescent gunnel	2	1	36	0	1	40
	Saddleback gunnel	0	0	3	1	0	4
	Snake prickleback	1	14	76	0	4	95
	Gunnels spp.	0	2	0	6	1	9
Tubefish	Tubesnout	3	4	14	53	2	76
	Threespine stickleback	2	1	2	3	1	9
	Bay pipefish	0	0	0	1	0	1
Others	Skate spp.	2	2	3	1	0	8
	Geenling spp.	1	1	2	0	1	5
	Cod spp.	0	1	3	2	0	6
	Midshipman	0	0	2	0	0	2
	Ratfish	1	0	0	0	0	1
	Totals per Site:	**3,615**	**3,786**	**6,492**	**2,423**	**1,062**	**17,378**

Table 3-3
Summary of Total Salmonids Caught by Month in 2001

	May						June					
	Chinook	Coho	Chum	Sockeye	Cutthroat	Steelhead	Chinook	Coho	Chum	Sockeye	Cutthroat	Steelhead
Picnic Point	7	14	66	0	10	1	0	9	0	0	10	0
Meadowdale	36	9	56	0	9	0	2	3	0	0	43	1
Ocean Ave	14	1	203	0	1	0	7	2	1	0	0	0
Richmond Beach	21	2	671	0	0	1	29	20	6	38	1	0
Carkeek	5	0	68	0	1	0	4	3	0	1	0	0
Total per species:	83	26	1064	0	21	2	42	37	7	39	54	1
Total per month:	1196						180					

	July						August					
	Chinook	Coho	Chum	Sockeye	Cutthroat	Steelhead	Chinook	Coho	Chum	Sockeye	Cutthroat	Steelhead
Picnic Point	0	3	0	0	4	0	8	0	0	0	2	0
Meadowdale	22	3	1	2	11	0	2	1	0	0	6	0
Ocean Ave	1	0	0	0	0	0	5	0	0	0	0	0
Richmond Beach	1	1	0	0	1	0	1	0	0	0	0	0
Carkeek	44	9	0	0	1	0	4	0	0	0	0	0
Total per species:	68	16	1	2	17	0	20	1	0	0	8	0
Total per month:	104						29					

	September						October					
	Chinook	Coho	Chum	Sockeye	Cutthroat	Steelhead	Chinook	Coho	Chum	Sockeye	Cutthroat	Steelhead
Picnic Point	7	4	0	0	19	0	0	0	0	0	0	0
Meadowdale	1	0	0	0	24	0	0	0	0	0	27	0
Ocean Ave	3	0	0	0	0	0	1	0	0	0	0	0
Richmond Beach	8	0	0	0	0	0	0	0	0	0	0	0
Carkeek	2	0	0	0	0	0	0	0	0	0	0	0
Total per species:	21	4	0	0	43	0	1	0	0	0	27	0
Total per month:	68						28					

3.4.2 Hatchery vs. Wild Salmonids

To help distinguish between hatchery and wild salmonids, presence (unclipped) or absence (clipped) of the adipose fin was noted, as was the detection of a CWT. Of the 235 chinook sampled, 200 records were taken to make this distinction (Table 3-4). During the study period, 109 clipped chinook were captured of which 29 were coded-wire tagged. In addition, 91 unclipped chinook were captured of which 7 were coded-wire tagged. Of the 84 coho salmon captured, 13 were clipped and 71 were unclipped (Table 3-5).

Size of all chinook measured (n=199) ranged from 72 to 247 mm, with clipped chinook (n=108) ranging from 74 to 247 mm and unclipped chinook (n=91) ranging from 72 to 176 mm. Size of coho measured (n=67) ranged from 94 to 540 mm, with clipped coho (n=12) ranging from 125 to 217 mm and unclipped coho (n=55) ranging from 94 to 540 mm.

Coded-wire tagged fish collected during this study were sent to the WDFW decoding labs in Olympia. Data are currently being analyzed to determine point of release, time released, and growth. For coded-wire tags that have been decoded at the time of this report, it has been determined that the CWT fish found in the study area came from six different hatcheries located in six different watersheds listed below:

- Marblemount Hatchery on the Skagit River;
- Whitehorse Rearing Pond on the Stillaguamish River;
- Wallace River Hatchery on the Snohomish River;
- UW Portage Bay Hatchery in Portage Bay;
- Soos Creek Hatchery on the Green River; and
- Groover's Creek Hatchery on Groover's Creek in Kitsap County.

Current hatchery release practices make it difficult to determine point of release as hatchery fish marked for release at a specific location may actually be released at other locations. While the marking (i.e., clipped) and tagging (i.e., CWT) of fish does provide some assurance that fish are of hatchery origin, not all hatchery fish are marked or tagged and limited numbers of wild fish are currently being marked and/or tagged for other management purposes. These practices limit the ability to make definitive conclusions about the composition of hatchery and wild salmonids captured.

Table 3-4
Summary of Clipped, Unclipped and CWT Chinook by Month in 2001

	May				June			
	Clipped Chinook		Unclipped Chinook		Clipped Chinook		Unclipped Chinook	
	CWT	Non CWT	CWT	non CWT	CWT	Non CWT	CWT	non CWT
Carkeek Park	0	2	0	3	0	3	0	1
Richmond Beach	2	7	0	3	0	8	0	18
Meadowdale	8	2	0	15	0	0	0	2
Ocean Ave	3	5	0	6	0	0	0	6
Picnic Point	3	1	0	3	0	0	0	0
Totals:	16	17	0	30	0	11	0	27

	July				August			
	Clipped Chinook		Unclipped Chinook		Clipped Chinook		Unclipped Chinook	
	CWT	Non CWT	CWT	non CWT	CWT	Non CWT	CWT	non CWT
Carkeek Park	5	20	3	8	0	2	0	2
Richmond Beach	1	0	0	0	0	0	1	0
Meadowdale	2	13	2	5	0	1	0	1
Ocean Ave	0	0	0	1	1	3	0	1
Picnic Point	0	0	0	0	3	2	1	2
Totals:	8	33	5	14	4	8	2	6

	September				October			
	Clipped Chinook		Unclipped Chinook		Clipped Chinook		Unclipped Chinook	
	CWT	Non CWT	CWT	non CWT	CWT	Non CWT	CWT	non CWT
Carkeek Park	0	1	0	1	0	0	0	0
Richmond Beach	1	4	0	3	0	0	0	0
Meadowdale	0	1	0	0	0	0	0	0
Ocean Ave	0	2	0	1	0	1	0	0
Picnic Point	0	2	0	2	0	0	0	0
Totals:	1	10	0	7	0	1	0	0

Table 3-5
Summary of Clipped and Unclipped Coho by Month in 2001

	May		June		July	
	Clipped	Unclipped	Clipped	Unclipped	Clipped	Unclipped
Carkeek Park	0	0	0	3	4	5
Richmond Beach	0	2	3	17	1	0
Meadowdale	0	9	0	3	0	3
Ocean Ave	0	1	0	2	0	0
Picnic Point	1	13	3	6	1	2
Totals:	1	25	6	31	6	10

	August		September		October	
	Clipped	Unclipped	Clipped	Unclipped	Clipped	Unclipped
Carkeek Park	0	0	0	0	0	0
Richmond Beach	0	0	0	0	0	0
Meadowdale	0	0	0	1	0	0
Ocean Ave	0	0	0	0	0	0
Picnic Point	0	0	0	4	0	0
Totals:	0	0	0	5	0	0

3.4.3 Dietary Analysis

A total of 174 samples (whole fish, stomachs, or lavaged) were collected for dietary analysis at the five sites during the study period (Table 3-6). Chinook samples (n=126) were collected at all sites and throughout the study period, whereas other salmonid samples were collected when available and primarily early in the season. Early samples consisted primarily of whole fish due to the lack of lavage equipment and the desire to utilize CWT fish that were already being sacrificed for CWT extraction and decoding. Once lavage equipment was available in the field, fish were only intentionally sacrificed if they were to be sent for CWT analysis. Samples are currently being analyzed at the University of Washington and a separate report will be prepared following analysis of 2001 and 2002 samples from all sites surveyed (n = approximately 700).

Table 3-6
Number and Type of Sample Collected for Dietary Analysis at Each Site in 2001

	Chinook			Coho		
	Whole Carcass	Lavage	Stomach	Whole Carcass	Lavage	Stomach
Carkeek Park	3	11	11	0	0	0
Richmond Beach	14	17	1	4	0	0
Meadowdale	19	11	3	3	0	0
Ocean Ave	1	15	7	0	0	0
Picnic Point	4	9	0	4	0	0
Totals:	**41**	**63**	**22**	**11**	**0**	**0**

	Chum			Sockeye		
	Whole Carcass	Lavage	Stomach	Whole Carcass	Lavage	Stomach
Carkeek Park	0	0	0	1	0	0
Richmond Beach	10	0	0	7	0	0
Meadowdale	5	0	0	1	0	0
Ocean Ave	0	0	0	0	0	0
Picnic Point	13	0	0	0	0	0
Totals:	**28**	**0**	**0**	**9**	**0**	**0**

4.0. SPOT PRAWN

The following section provides existing information on geographic range, habitat, life history, and the fishery for the spot prawn, *Pandalus platyceros*, the largest shrimp inhabiting Puget Sound. The spot prawn, also referred to as spot shrimp, gets its name from the characteristic white spots on the first and fifth segments of the carapace (behind the head and in front of the tail). This species is of both commercial and recreational importance and supports a large fishery within Puget Sound.

4.1 Geographic Range and Habitat

In the northeastern Pacific, spot prawns occur in marine waters from Alaska to southern California. Within Puget Sound, spot prawns are found in discrete areas called 'beds', with the exception of Hood Canal where their distribution is more continuous (WDFW, 1995). Puget Sound waters between the depths of 61 to 91 meters (200-300 feet) are believed to support spot prawn populations, although their distribution and density within these depths is patchy (Mormorunni, 2001; Velasquez, 2002). Spot prawns occur at much deeper depths in other areas throughout their distribution range, particularly in Alaskan waters. Factors determining distribution, including size and location of the beds, are not clear but may be influenced by the availability of complex habitat for adults and larval transport (Mormorunni, 2001). In the Central Basin of Puget Sound, there are known spot prawn beds between the 61 to 91 meter depth range from Edwards Point north to about Ocean Avenue (midway between Brackett's Landing and Browns Bay) and in a smaller area along those same depth contours off Point Wells (Velasquez, 2002). Figure 4-1 shows the location of known spot prawn beds in the vicinity of the candidate outfall zones.

During various stages of their life cycle, spot prawns may be found over a wide range of depths throughout their entire range, from intertidal areas down to a maximum depth of 487 meters (1597 feet)(WDFW, 1995). Spot prawn habitat requirements are dependent on the developmental stage of the animal with adult, juvenile, and larval spot prawns using different habitat types. Adults occupy deeper waters and juveniles are known to occupy shallower waters where vegetation is present (WDFW, 1995). Both juveniles and adults typically occupy bottom substrates, whereas larval spot prawns inhabit the water column and their movements are influenced by tides and currents.

Adult spot prawns typically inhabit rocky or hard-bottom substrates, including rocky slopes, reefs, coral, and sponge beds, however, they may also be found over finer substrates (WDFW, 1995). Typical depths for adults, throughout their entire distribution range, are between 198 and 234 m (653-722 feet) but there are regional depth preferences (Mormorunni, 2001). In British Columbia, adults are most abundant between 70 and 90 m (DFO, 1999) and in Puget Sound waters, adults are most abundant between 61 and 91 meters (200-300 feet) (Velasquez, 2002). Adult spot prawns may move into shallower waters at night to feed, however, they do not migrate to any significant extent which can lead to many localized populations. There are also seasonal migrations from deep to shallow waters and they can migrate vertically in the water column (WDFW, 1995).

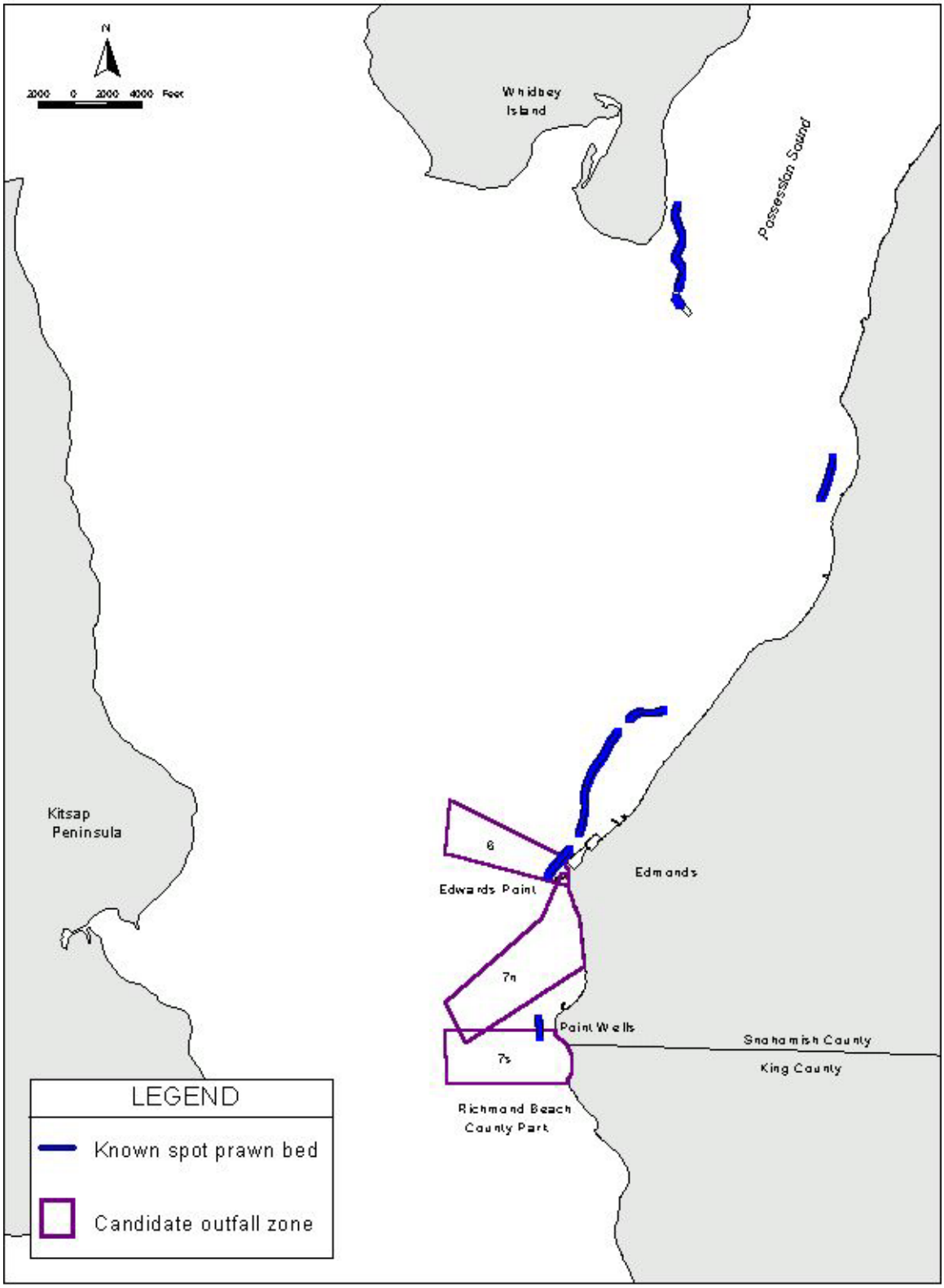

Figure 4-1. Location of Known Spot Prawn Beds Near the Candidate Outfall Zones

Juvenile prawns are able to tolerate greater temperature and salinity ranges than adults and are found in shallower water than adults. In Puget Sound waters, juvenile prawns with a carapace length less than 15 millimeters tend to concentrate in waters less than 15 m deep(WDFW, 1995). As the juveniles mature, they migrate to deeper waters (Magoon, 1979).

The early larval stages and adults are typically found in waters with salinities between 29 to 35 practical salinity units (PSU) but salinities down to 26 PSU do not significantly impair larval survival (WDFW, 1995). Salinities below 23 PSU, however, have shown significant mortality to adult spot prawns (WDFW, 1995).

The most significant natural constraint on Puget Sound spot prawn populations appears to be the lack of suitable juvenile habitat. In contrast, an abundance of suitable adult habitat (i.e., rocky slopes) is available and supports a few spot prawn stocks (WDFW, 1995).

4.2 General Life History

The spot prawn is a crustacean in the family Pandalidae. It is the largest member of the pandalid shrimp with a maximum length up to 25.4 centimeters (10 inches) (Mormorunni, 2001). They are light brown to bright orange in color and have characteristic white spots behind the head and in front of the tail, which distinguishes them from other pandalid shrimp. Adults may also have white stripes running the length of their body.

Life-history characteristics, particularly growth and age, vary over their geographic range and growth rates increase in warmer waters of their southern range. Studies in Canada indicate that spot prawns may live approximately four years, whereas studies in California have shown they may live up to six years. The life span of spot prawns is in Washington waters has not been documented (Mormorunni, 2001).

All spot prawns start their lives as males and can reach sexual maturity by their third year. By their fourth year, most males begin changing sex and enter a transitional stage. By the end of the fourth year, most males have become females (Mormorunni, 2001). The majority of females breed only once before dying. Breeding takes place in deep waters in the fall and females carry the fertilized eggs under their tails on specialized appendages for about four to five months until they hatch, usually over a 10-day period (Mormorunni, 2001). Once hatched, the larvae are planktonic and can spend up to three months in the water column before settling out onto the bottom as juveniles in the late summer (DFO, 1999). Before they settle out as juveniles, the larvae pass through nine stages over a period of about 80 days as they feed on plankton (McCrae, 1994; WDFW, 1995). When the larvae start to settle out, they migrate to inshore areas where they are thought to enter a sedentary stage and remain on the bottom (Mormorunni, 2001).

Spot prawns are bottom feeders and forage on mysid and other shrimps, amphipods, small mollusks, fish carcasses, and polychaete worms (McCrae, 1994). Their predators are rockfish, ling cod, flatfish, harbor seals, octopi, and humans (DFO, 1999; WDFW, 1995). The adults forage mainly at night.

4.3 Commercial and Tribal Spot Prawn Fisheries

The spot prawn fishery is divided into four types of management and allocation zones: Management Regions, Catch Areas, Shrimp Districts, and Special Management Areas. Harvest quotas for state and tribal fisheries are establised for each Management Region and/or Catch Area based on historical landings (amount harvested) and catch rates. The candidate marine outfall zones are within the state's Management Region 4, Catch Area 26B for pandalid shrimp. This area includes waters in the Puget Sound Central Basin from the tip of Vashon Island north to Point Edwards (eastern boundary) and Apple Cove Point (western boundary) (Figure 4-2). The northern portion of Zone 6 is within Management Region 2W, Catch Area 26A. This Catch Area includes waters within Admiralty Inlet as well as the area north of Point Edwards, including Brackett's Landing and Meadowdale Beach Park (Velasquez, 2002). The State compiles all non-tribal harvest data. The Tulalip Tribe reports tribal catches in Management Region 2 and the Suquamish Tribe reports tribal catches in Management Region 4 (WDFW, 2001).

Washington State has had significant spot prawn fisheries since the late 1940's. The Puget Sound fishery includes both tribal and state commercial fisheries. In Puget Sound inland waters, excluding Hood Canal, most fishing occurs in the eastern and central potions of Puget Sound. Since the 1994 Rafeedie Decision, Washington State Tribes and WDFW have shared responsibility for spot prawn management and for allocating harvest levels equitably between tribal and non-tribal fishers (Mormorunni, 2001).

The state commercial fishery is currently limited to 18 licenses and establishes trip limits. The state commercial fishery remains open for one to two months, typically from June until the end of July (Mormorunni, 2001). The tribal fishery is an open-access fishery that does not use trip limits, therefore, the quota is typically caught quickly and the fishery only lasts about two weeks per season (Mormorunni, 2001). Tribal quotas are primarily caught in central Puget Sound and the catch is monitored both pre- and post-season. Catch Areas 26A and 26B in the candidate outfall zones are two areas that open early to spot prawn fishing if test fishing shows that fewer than 2% of the females have eggs. Test fishing samples must contain a minimum of 100 prawns with a minimum carapace length of 30 mm (1.18 in.) and come from two different sampling areas (Mormorunni, 2001). If less than 2% of the females have eggs, then fishing is allowed in Catch Areas 26A and 26B before April 11 through October 15, or until the quotas are reached. In other areas, the general season for fishing is April 16 through October 15, or until quotas are reached (Mormorunni, 2001). Ceremonial, subsistence, and recreational fisheries are open in all areas except certain Shrimp Disctricts outside the outfall zone areas from April 11 to October 15, or until quotas are reached.

Pots are the only legal gear allowed for the spot prawn fishery and the shrimp trawl fishery are not allowed to retain spot sprawns caught incidentally (Mormorunni, 2001). All prawns retained in the pot harvest must have a minimum carapace length of 30 millimeters. It is not legal to pull or set pots from one hour after sunset to one hour before sunrise. All commercial prawns harvested must be sold to licensed Washington State wholesale fish dealers. The harvest allocation for the state fishery in Management Regions 2 and 4 is 40% commercial, 60 % recreational (Mormorunni, 2001).

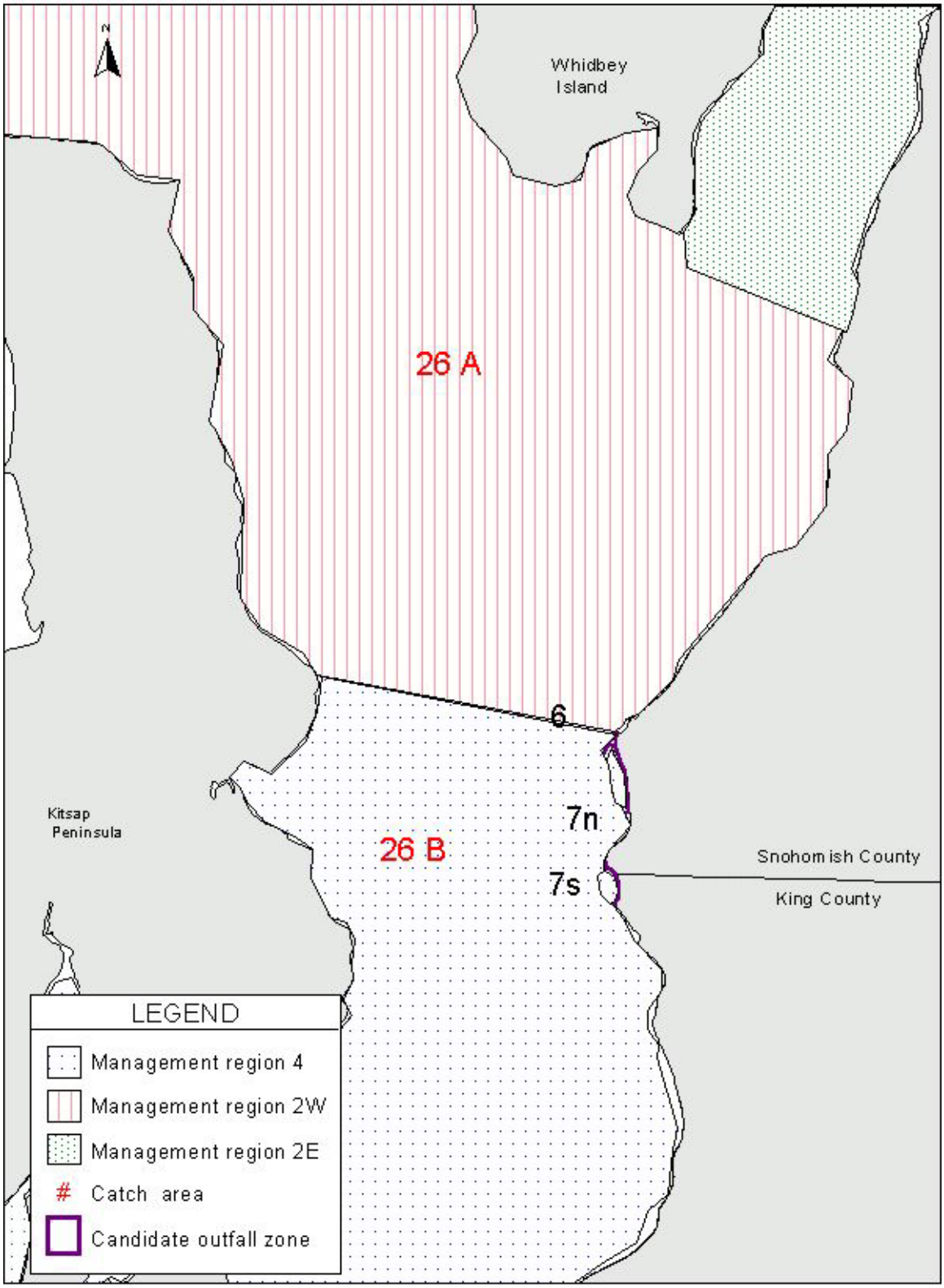

Figure 4-2. Spot Prawn Management Regions and Catch Areas Near Candidate Outfall Zones

The allowable tribal pot harvest fishery in 2001 for spot sprawns within Catch Area 26 was 6,000 pounds along the eastern shore from Point Edwards north to the eastern boundary of the area and seaward to the 183 m depth contour. From all other waters in Catch Area 26, 3,000 pounds was the allowable catch (WDFW, 2001).

In 2001 for the pot fishery, the allowable tribal harvest in Catch Area 26B was 7,300 pounds and the State harvest (non-Tribal) was also 7,300 pounds. A total of 9,000 pounds was harvested from the Elliott Bay sub-area (26B-3), 2,000 pounds from the northern Bainbridge Island sub-area (26B-2), and 3,600 pounds from the southern Bainbridge Island sub-area (26B-1) (WDFW, 2001). Harvesting in both the Bainbridge Island sub-areas at the same time is not allowed and the harvest seasons are adjusted to ensure both areas are not open concurrently.

4.4 Data Gaps

Little information is known on the distribution and abundance of juvenile spot prawns in shallow waters. Current survey techniques do not incorporate methods that allow for the distribution and quantification of juvenile and larval prawns. There is also little information regarding temporal variability in distribution and abundance by age class. Although spot prawns forage on a variety of prey, little is known about which prey species are the most significant food items (WDFW, 1995).

There has been little research on spot prawn life-history characteristics in Washington waters and the information regarding pandalid shrimp stocks in Washington is limited (Mormorunni, 2001).

5.0. REFERENCES

Department of Fisheries and Oceans (DFO). 1999. Prawn, *Pandalus platyceros*, off the West Coast of Canada. DFO Science Stock Status Report C6-07.

Fresh, K.L., R.D. Cardwell, and R. P. Koons. 1981. Food habits of Pacific salmon, baitfish, and their potential competitors and predators in the marine waters of Washington, August 1978 to September 1979. Progress Report No. 145, Washington Department of Fisheries, Olympia, Washington.

Healy, M.C. 1980. Juvenile Pacific salmon in estuaries: the life support system. *In* V.S. Kennedy *Ed*. Estuarine Comparisons. Academic Press, New York, NY. pp.315-341.

Healey, M. C. 1982. Juvenile Pacific salmon in estuaries: the life support system. Pages 315-341 *in* V. S. Kennedy, editor, Estuarine Comparisons. Academic Press, New York.

King County Department of Natural Resources (King County). 2001a. Detailed Evaluation Questions Marine Outfall Siting Study. Technical memorandum, March 2001.

King County. 2001b. Phase 2 Detailed Evaluation Questions Marine Outfall Siting Study. Technical Memorandum, September 2001.

King County. 2001c. Application of Phase 2 Detailed Evaluation Questions Marine Outfall Siting Study. Technical Memorandum, September 2001.

King County. 2001d. King County Marine Habitat Report. Prepared in support of the Wastewater Treatment Division Habitat Conservation Plan and the Brightwater Marine Outfall Siting Study. Submitted by Striplin Env. Assoc, Battelle Marine Sciences Lab., and King County DNR.

King County. 2001e. Phase 2 Technical Memorandum Marine Outfall Siting Study, Appendix E. Biological Resources Report. Prepared by Striplin Env. Assoc, Parametrix, and King County DNR.

King County. 2002. *Brightwater Phase 3 Preliminary Conveyance Evaluation Summary*. King County Department of Natural Resources and Parks. July 2002.

Magoon, C. D. 1979. Shrimp Fishing in Washington. Wash. Dept. Fish., Information Booklet No. 3. 24 pp.

McCrae, J. 1994. Spot Prawn, *Pandalus platyceros*. Oregon Developmental Species. Oregon Dept. of Fish and Wildlife.

Mormorunni, 2001. The Spot Prawn Fishery: A Status Report. A project of the Asia Pacific Environmental Exchange, Seattle, WA.

Moulton, L.L. and D. Penttila. 2000. Forage Fish Spawning Distribution in San Juan County and Protocols for Sampling Intertidal and Nearshore Regions. Final Report. San Juan County Forage Fish Assessment Project. Marine Resources Committee, San Juan County, Friday Harbor, WA.

Penttila, D. 2001. Dan Penttila from Washington Dept. of Fish and Wildlife personal communication to Kevin Li, King County Environmental Laboratory, in November, 2001.

Robinette, R. L., and J. C. Ha. 1997. The significance of fishing by Northwestern crows. Wilson Bulletin 109: 748-749.

Simenstad, C.A. 1991. Estuarine Habitat Assessment Protocol. US Environmental Protection Agency, Region 10. Seattle, WA. 201pp.

Simenstad, C. A., and K. L. Fresh, and E.O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 *in* V.S. Kennedy, editor, Estuarine Comparisons. Academic Press, New York.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech (Management Technology) Environmental Research Services Corp., Corvallis, Oregon.

Thom, R. M. 1987. The biological importance of Pacific Northwest estuaries. Northwest Environmental Journal 3(1): 21-42

Velasquez, D. 2002. Personal communication (maps and spot prawn pot fishery landing data) from Don Velasquez at Washington Department of Fish and Wildlife, Mill Creek Office, to Kimberle Stark, King County DNR, March 21, 2002.

Washington Department of Fish and Wildlife (WDFW). 2001. Puget Sound (Excluding Hood Canal) Pandalid Shrimp Harvest Management Plan for Fisheries Conducted by U.S. v. Washington Subproceeding 89-3 Treaty Tribes and State of Washington. Olympia, WA.

Washington Department of Fish and Wildlife (WDFW). 1995. Draft Report on Spot Shrimp, *Pandalus platyceros*, 10 pp. WDFW, Olympia, WA.

Woodruff,D.L., P.J. Farley, A.B. Borde, J.S. Southard, and R.M. Thom. 2001. King County Nearshore Habitat Mapping Data Report: Picnic Point to Shilshole Marina. Prepared for King County Dept. of Nat. Resources.